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Commonwealth of Pennsylvania
BOARD OF FISH COMMISSIONERS

METHODS EMPLOYED IN PRODUCING
THE BULLFROG (*Rana Catesbiana*)
TADPOLES

AT THE
PENNSYLVANIA STATE HATCHERIES

By
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Deputy Commissioner of Fisheries



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BOARD OF FISH COMMISSIONERS

Harrisburg, Pa.

METHODS EMPLOYED IN PRODUCING THE BULLFROG (*RANA CATESBIANA*) TADPOLES AT THE PENN- SYLVANIA STATE HATCHERIES

By C. R. Buller, Deputy Commissioner of Fisheries

Because of the thousands of bullfrog tadpoles sent out each year for distribution, many people are of the opinion that the frogs are confined and reared under strictly artificial conditions, and for this reason, persons desirous of entering into the rearing of frogs, on a commercial scale, call upon us for information as how to proceed. To my knowledge, there are no successful frog farms in operation, where the stock is confined and reared under artificial conditions, as is being done at the fish hatcheries, with various species of fish.

The following article was prepared to show the method of obtaining the tadpoles, and to point out some of the factors that would have to be taken into consideration, if frogs and tadpoles were too closely confined.

Our tadpoles are produced in connection with the rearing of certain species of warm water fish. This work is carried on in ponds, ranging in area from one-half to one hundred acres, where a more or less natural condition exists with reference to aquatic plant life, water temperatures, etc., which make ideal places for a limited number of different species of frogs to live and reproduce.

Before entering into discussion of the bullfrog (*Rana catesbiana*), we will first consider to what class of animals a frog belongs, and what transpires in its change from the larva stage to that of the adult.

Frogs, toads, salamanders, and newts are cold-blooded vertebrates, belonging to an animal class called Amphibia, and which if literally translated from the Greek, means a creature of two lives. The typical Amphibia, after hatching from the egg, begins life as a legless, fish-like creature, possessing gills, an eel-like tail and lives wholly within the water. This is the larva stage of the creature. Later on legs make their appearance, the tail disappears, being absorbed into the body, the digestive system changes from a simple to a complex form, lungs take the place of gills and the creature emerges in the adult form, fitted for a life on land, if it so desires. These stages of development or changes in the life of the creature, are called metamorphosis, and are typical of the frogs found about the hatchery grounds. The larva form of the frog is known as the frog tadpole.

Because the bullfrogs have a free range of the property, living and depositing their eggs in almost any of the ponds to their liking, it follows that other species of frogs besides the bullfrog, are present and

must be considered. The three most prevailing species, other than the bullfrog, are the pickerel frog (*Rana pulustris*), the leopard frog (*Rana pipiens*), and the green frog (*Rana clamitans*). I will state briefly, some of their identification marks, natural habitat in Pennsylvania, range in North America, spawning habits, etc.

PICKEREL FROG

Identification Marks:—The ground color of the upper parts is brown, with the under parts of the legs and belly an orange yellow. The under parts of the lower jaw are white, sometimes marked with brown. On each side of the back is a low, broad fold of skin (the lateral fold), extending from the eye backward. Between these folds, on the back can be found four, more or less conspicuous folds. Between the lateral folds, also on the back, are two, more or less, opposite rows of dark, squarish spots and below the lateral folds, on each side, two irregular rows of dark spots, generally somewhat smaller than those found on the back. The legs are barred or irregularly spotted.

Range in North America:—Throughout the eastern part, east of the Great Plains and north to Hudson Bay.

Size:—From 2 to 3 inches in body length, measuring from the tip of the muzzle to the posterior end of the body, probably too small to have much of a commercial value. Another objectionable feature, from a commercial standpoint, would be the secretion of acid substance in the skin.

Natural Habitat in Pennsylvania:—The pickerel frog spends little of its time in the water, but enjoys being nearby, where it can keep its skin moist, seek protection, and deposit its eggs. During extended periods of damp or rainy weather, it wanders considerable distance from the water side, probably in search of caterpillars, butterflies, millers, gnats, beetles, etc., but during dry weather, it is inclined to stay near the water, where it probably feeds upon the type of small life that makes its home about the shore lines.

Spawning Habits:—In Pennsylvania, the eggs of the pickerel frog are deposited in May or June, generally along the shore lines, in shallow water. When deposited, the eggs are in the form of a more or less irregular mass, several inches in diameter. After hatching, the tadpole develops into the frog, in July or August of the same year.

LEOPARD FROG

Identification Marks:—The ground color of the upper parts may be green, gray or brown, which sometimes changes rapidly from one color to the other. The under parts are white or yellowish white. The legs are marked with dark spots or bands. On each side of the back, is a conspicuous, broad, lateral fold, with two or more broken folds of skin extending lengthwise along the back between the lateral folds. Between these folds may be found two irregular rows of dark, round spots and below the folds on each side are two additional rows of irregular, dark spots.

Range in North America:—The leopard frog is probably the most common frog in North America, east of the Sierra Nevada Mountains.

Size:—When fully matured, ranges in size next to the green frog measuring from 3 to 4 inches.

Natural Habitat in Pennsylvania:—The habitat of this species, like that of the pickerel frog is not, as a rule, in the water, but nearby. In damp, wet weather it is often found wandering considerable distance from its aquatic home, which may be any body of water, large or small. Its natural food consists of earthworms, insects, spiders, other frogs, and in fact, almost any kind of life, small enough to be swallowed.

Spawning Habits:—Spawning takes place in April or May. The eggs are usually deposited in shallow water, where they may be attached to sticks, grass, etc., or left free. The tadpole develops into the frog in July or August of the same year.

GREEN FROG

Identification Marks:—The color of this frog is extremely variable, although the typical color is bright metallic green on the head and shoulders, and dark olive or brown, posteriorly. The under parts are white with some marbling, the sides of the body may be marked with large, dark blotches. In some instances, the throat of the male is bright orange, while that of the female may be white, spotted with dark. It has two conspicuous ridges or lateral folds, down either side of its back.

Range in North America:—Commonly found throughout the eastern portion, including Canada and Florida.

Natural Habitat in Pennsylvania:—The green frog is quite aquatic spending much of its time in the water. While it is found quite commonly about springs, small ponds, or small creeks, it appears to have quite a liking for large bodies of still water, as lakes, mill ponds, quiet portions of large streams and rivers, where it spends much of its time in the shallow water, along the grassy shore lines, feeding upon insect life, tadpoles, small frogs, and small animal life in general.

Spawning Habits:—The spawning is rather extended, eggs being found from May 1 to July 1 and probably later, depending much upon the weather temperatures. The eggs are deposited in about the same places as those of the bullfrog, but the egg mass is probably more commonly found floating. From the time the egg hatches into the tadpole, it requires one year or more before it develops into the frog.

BULL FROG

Identification Marks:—The upper parts vary in color from green to greenish brown, with shades ranging from light to very dark. The back and sides may be plain in color or may be spotted with dark. These spots when present, may be distinct or connected. The arms and legs also, may be spotted or barred with dark. Its under parts are yellowish white, either plain, or spotted, or mottled with dark. It has no lateral folds or ridges down either side of its back, although a strong

fold of skin extends from behind the eye to the arm, curving around the ear. To the uninformed, the green frog and the bullfrog might be easily confused. The bullfrog is easily identified from the former by the absence of the lateral fold.

Range in North America:—East to the Rocky Mountains, including Florida and Texas.

Size:—The largest of the Pennsylvania frogs. The adult specimen often measuring from 6 to 8 inches in body length.

Natural Habitat in Pennsylvania:—The bullfrog is more aquatic than any of the other Pennsylvania frogs. It rarely strays from the water for any distance, unless disturbed by enemies, and prefers large areas, as lakes, ponds, and quiet running streams. It is very voracious, feeding upon almost any life, small enough to be swallowed.

Spawning Habits:—This frog is the last of these four species to spawn. The spawning may take place any time from June 15 to August 1, depending upon the water and air temperatures. The size of the egg mass is comparatively large, oftentimes measuring as much as 5 sq. feet. The eggs are deposited in various places, such as around submerged, or partly submerged stumps, rocks, aquatic plants, brush, etc. The depth may range from those floating on the surface, to those submerged several feet. The tadpole requires two years or more, before it develops into the true form of a frog.

BULLFROGS (*RANA CATESBIANA*) ON THE STATE HATCHERY GROUNDS

The habits of the bullfrog described below, are as we find them in and about the hatchery fish ponds, and I presume their habits in their wild habitat would be much the same as in this climate, because they are not confined but live in a natural state.

In rearing certain species of warm water fish, as the bass, sunfish, catfish and others, we use every means possible to make conditions natural with the result that many of the ponds contain submerged logs, brush, rocks, an abundant growth of aquatic plants, and in many instances a portion of the banks overhanging with such water loving plants as the alders, willows, etc. By creating these conditions we attract various insects and other organisms that live and reproduce in or about the ponds, that would otherwise not be there, thus creating by their presence a supply of natural fish food that cannot be substituted by any artificial foods yet devised. These conditions as well as being beneficial to fish life, make ideal places for the homes and the reproduction of the bullfrogs.

Food:—The food of the frog consists of almost any kind of animal life found in and about the water, that is small enough to be swallowed, such as earthworms, insects, crayfish, fish, tadpoles, and other frogs, including those of their own kind. In fact, they seem to have an instinct to snap at any small moving object coming within their range. I have said moving object, for the reason that we have not been able to induce a bullfrog to feed upon food that was not in motion.

In our hatchery aquariums we have on exhibition a number of bull- from observations in the aquariums, I am led to believe, that the we have tried to induce them to feed upon dead food, such as chopped meat, dead fish, cereals, etc., and in every instance they would die of starvation before consuming an object that was not in motion.

Just to what extent in nature they feed upon fish, I do not know. But from observations in the aquariums, I am led to believe, that the number of fish taken is very small, as they appear to be very awkward fishermen, generally making many attempts before capturing their prey.

How Sex is Distinguished:—A sure way of telling the sex, particularly at the approach and during the breeding season, is that the first finger of the hand of the male is greatly enlarged, especially at the base. The swelling appears to be due mainly to the enlargement of the granular portion of the skin in this region. The ear of the male is much larger than that of the female, but one can easily become confused unless there is at hand individuals for comparison.

The female is usually more brown and spotted, and the male more evenly plain green. The male oftentimes has a bright yellow throat, while that of the female is yellowish white, or white mottled with brown. Because the color varies greatly, not only according to sex, but among individuals of the same sex, color markings cannot be relied upon.

Enemies:—The enemies of the frog, in and about the hatchery grounds, are many. Consisting in part, of crows, herons, hawks, cranes, minks, water rats, snakes and fish, and because of their cannibalistic habits, they are enemies of one another. Disease is also probably a serious enemy, but to just what extent, I have no knowledge.

As frogs are one of the most defenseless of animals, they must depend on certain instincts of self-preservation for their existence, some of which are interesting. Bass are particularly fond of small frogs and tadpoles, although an average sized bass will rarely molest an adult bull-frog.

A number of years ago, the major portion of the Union City Hatchery was devoted to bass culture, with the result that few frogs were to be found in that vicinity. After the bass work was discontinued, and the ponds devoted to such fish as the yellow perch, sunfish, and catfish, adult frogs soon start to make their appearance, and today this hatchery has for distribution more tadpoles than any other of the state hatcheries.

Unit No. 3, a portion of the Pleasant Mount Hatchery, was one time devoted to the culture of yellow perch, catfish, and sunfish, at which time the area contained many adult frogs, and yearly produced a remarkable crop of tadpoles. Three years ago this area was changed into a bass unit, with the result that the majority of the adult frogs gradually migrated to more favorable quarters, where their offspring would be afforded more protection. Another interesting observation I have made in this connection, is that when small sized frogs are thrown some distance from the shore of an adult bass pond, if a bass strikes at the frog and misses, the frog will lie on the water surface practically

motionless until the wind or current carries it to the shore. It seems to realize that it would be fatal to make a move. Bass prefer moving objects and will rarely touch the frog when not in motion. However, when thrown near the shore line, they will not resort to playing possum, but will make a desperate effort to reach land, before being overtaken.

Color changes are also great protection. For instance, during hibernation, frogs lying on the dark pond bottoms, will become very dark, making it difficult for them to be seen. As they leave their hibernation, and spend their time among the green vegetation of the shore and pond, they take on a lighter, greener color, which blends with the surrounding foliage.

When frightened by aquatic enemies, as the fish or turtle, if near the shore, it will seek protection on land. If frightened by land enemies seek protection by diving into the water, generally coming to the surface again, after a series of short, swift plunges, some distance away. Probably the reason the frog swims under water in a series of swift plunges, is because they swim with their eyes closed, and must stop frequently to get their bearings.

Hibernation:—Frogs spend probably one-half of the year or more, in hibernation. At the approach of fall they seek the pond bottoms, where the water depth will protect them from frost, and lie dormant until the coming spring. In some instances they bury into the mud of the pond bottoms, and in others stay under submerged logs, roots, rocks, etc.

During this period, they consume no food through the mouth, nor breathe any air through the lungs. They can live over those long periods, without feeding, for the reason that they are cold-blooded and their body activities lessen greatly with the lowering of the surrounding temperatures, which follows that during the winter months, with the water temperatures very near the freezing point, the general, vital activities of the animal run down so low that little expenditure of energy is required to keep alive. The little respiration required, takes place through the skin, and the small amount of nourishment is taken from materials stored in the tissues.

As compared with some other species, they are later coming from their hibernation. The time depending entirely, upon the air and water temperatures.

In drawing down our ponds in the late fall, we often find frogs in their winter quarters. If the temperatures are near the freezing point they are very helpless, lacking the ability to move. Where this is the case, those that can be found are collected and transferred to other quarters. In a number of instances, in the early fall months, we have taken frogs from their hibernation and transferred them to the hot-house. In a few days, after coming in contact with the warm atmosphere they take on a lighter color, become very active and start to feed ravenously, which follows that if frogs were confined where the yearly temperatures would be comparatively high, they would not hibernate, and would feed every month of the year. Just what effect this would have on the process of reproduction, I do not know.

Spawning Habits:—As before stated, in Pennsylvania the bullfrog deposits its eggs any time from June 15 to August 1, depending upon the water temperatures. The earlier the season, or the earlier the water temperatures raise, the sooner the spawning will take place. In some of our large ponds, say of one hundred acres, frogs that have made their homes in the shallow waters of bays or other protected areas, where the water temperatures are considerably higher than in the main body, spawning often times will take place several weeks in advance of those having homes in less protected areas.

During ovation, the male frog holds the female behind the forearms, his hands clasped to her breast. As the eggs are being extruded by the female, the male discharges his spermatic fluid over them, and fertilization takes place.

The Eggs:—The spawning habits of the green frog and the bullfrog are very similar. This also is true with respect to the places sought for depositing the eggs. As their spawning periods somewhat overlap, eggs of both species are found in the ponds at the same time and in similar places. They can easily be distinguished by certain technical differences, in a manner they will comprehend. For this reason, we generally depend for identification upon the size of the jelly mass. The masses of the green frog eggs are considerably smaller, counting from 3,000 to 5,000 to the string, which covers an area of from 10 to 14 inches in diameter, while the mass of the bullfrog eggs average from 10,000 to 25,000, and cover an area ranging from 18 to 24 inches in diameter.

Without question, the number of eggs deposited by a female will depend upon her age and size. From a commercial point of view, the large number of eggs deposited by the bullfrog, in comparison with the other species mentioned, can be looked upon with favor, as less breeders would be required to produce the desired crop of offspring.

When the eggs hatch, the tadpoles come forth in the form of tiny, black, helpless creatures, about three-sixteenth of an inch long. For the first few days of their lives, they can be seen in groups, clinging to submerged brush, aquatic plants, gravel, rocks, etc., but as they gain in strength, these groups break up and each individual leads a more or less, independent existence.

Experiments in Transferring Eggs:—The larger the tadpole, at the time of transformation into the perfect frog, the larger will be the frog. Thus, in our opinion, its chances of survival, will be proportionately increased over the smaller of its own kind. The rate of growth of the tadpole depends upon environmental conditions, with special reference to the water temperatures and food supply.

In rearing the tadpoles, in connection with fish culture, sufficient food for the maximum amount of tadpole growth, over a given period, cannot be introduced into the ponds, for fear of water contamination, which might prove fatal to the fish life. Again, four varieties of tadpoles are present in our ponds, during certain seasons of the year, all of which are consuming food intended for the bullfrog tadpoles.

With the thought of overcoming these conditions, in 1927, experiments were conducted in transferring bullfrog eggs from the various ponds and placing them in a tadpole nursery, where they could be

given the quantity of food needed for their rapid growth, and also do away with the expense of feeding the undesirable species. In various stages of their development, approximately one hundred egg masses were transferred into the nursery, with the result that very few hatched, and the experiment appeared to be a complete failure. The first thought was that the transfer had proven injurious to the egg. However, after checking up on the egg crop at the other hatcheries where they had not been molested, it was found that during this season, the mortality was exceptionally high among the eggs, just before hatching, and among the very young tadpoles that had hatched. This left a doubt in our minds whether the failure could be attributed to the handling of the eggs, or whether it was the disease among the eggs and the very young tadpoles that appeared to be prevalent throughout the state. Consequently, it is our thought, to try this experiment again, this coming year.

THE TADPOLE

Inasmuch as our parent frogs are not confined, but have free range of the hatchery ponds, it follows that other species of frogs would also use these ponds as spawning grounds. Probably 6 or 8 species of frogs eggs are deposited in the ponds throughout the seasons. The four following species, the bullfrog, the green frog, the leopard frog, and the pickerel frog, are considered as having economical bearing on the yearly distribution of our bullfrog tadpoles, and will be considered herein. By reviewing the spawning habits of the frog, it can readily be seen that before fall of the same year, the leopard and the pickerel frog tadpoles have left the pond, leaving by fall, the bullfrog and the green frog tadpoles on hand. The green frog tadpoles require one year or more before developing into the frog, and the bullfrog two years or longer.

Food of the Tadpole:—Besides the natural food, provided in the ponds, the tadpoles are fed upon clabbered cows milk and chopped sheep livers. The food is introduced during warm months in the shallow waters, along the shore lines. Feedings are made each day, of the amount that will be consumed over a period of a few hours, care being taken not to introduce sufficient tadpole food that might have a tendency to contaminate the water for the fish life. The rate of growth depends a great deal on the amount and kind of food available. In ponds, where conditions permit, heavily fed tadpoles show a remarkable growth over those less heavily fed.

Tadpoles are wonderful scavengers. They feed upon almost any kind of dead or decaying animal matter and for this reason, each spring, several hundred one-year old or older tadpoles are introduced into each one of the trout nursery ponds, where they consume any uneaten particles of food or dead fish, that might have been overlooked by the attendants. The tadpoles in these areas receive an abundance of food, and by fall it is not uncommon to find specimen 6 inches in length. For this work we try not to introduce the tadpole in the second year of its development, because after July they develop into the frog, and in the ponds having perpendicular sides where escape is shut off, if not removed, soon drown.

Enemies:—In their wild habitat, the enemies of the tadpole are many, including many kinds of birds, snakes, water insects, fish, frogs, and disease. In the hatchery ponds, the natural enemies are held more or less in check, with the possible exception of disease, which from my observations in both the hatchery ponds and the wild waters, takes a tremendous toll each year. It is probably the worst enemy. The mortality, as a rule, is the greatest just before or during the period they are changing into the frog form. Tadpoles can hardly be called enemies of one another, for the reason that they will not practice cannibalism, unless confined during warm weather, in very crowded conditions without food over a period of several days. In this case they will feed upon one another. By their rasp-like mouth they remove the protective slime from one another, where disease sets in, which eventually results in death and after death the tadpoles are quickly devoured.

THE TRANSITION PERIOD

From the time the bullfrog tadpole hatches from the egg, it requires approximately twenty-four months before it develops into the frog. By June and July of the second year, many tadpoles will already have developed the hind legs and a complete change in most instances, will take place during July and August. This change from tadpole to frog, is a delicate period of the creature's life and results in the loss of many each year. In order to comprehend more clearly, the changes that take place, when this creature changes from a form fitted to live exclusively in the water, to one fitted for life on land, we will again review just what takes place.

The hind legs first appear, budding out as small papilla on either side of the base of the tail. As they grow they become jointed in structure and gradually take on the true shape of the foot and leg. The front limbs make their appearance in much the same manner as the hind ones. The eye becomes larger and more conspicuous, showing a slight elevation, a characteristic of the true frog. The small mouth broadens and increases in size. The tongue becomes larger. The rounded body takes on the characteristic shape of the frog. The gills are absorbed, lungs grow and take their place. The intestinal tract undergoes important changes, becoming much shorter. The ear membranes develop, color changes take place, and the tail is absorbed in the body, until only a mere, black stump is left. In fact the animal is changed from a fish-like creature, living wholly within the water and breathing through gills, into a lung breathing creature, equipped with limbs for life on land. The changes undergone in the transformation, are not just in the order named, but all take place in period of a few weeks after the hind legs appear. The tail does not drop off as is generally supposed, but is absorbed in the body, probably furnishing the creature with nourishment, during this critical stage.

THE BABY FROG

My knowledge as to the habits of the baby frog is very limited, but I presume its habits are much the same as that of the adult.

Rate of Growth:—In the hatchery, the rate of growth of a tadpole depends chiefly upon the amount of food and the water temperatures, and I presume this also has a great bearing on the rate of growth of

the frog. No experiments have been conducted by the Board to determine the average yearly growth of either, but from comparison of the various sized frogs found upon the hatchery grounds, I am led to believe that the average yearly growth is about one inch. That is it would take about five years for a frog to grow a body length of five inches. As to the exact age that the frog reaches sexual maturity, I am somewhat in doubt, but probably about the third or fourth year.

HOW THE BULLFROG TADPOLES ARE SEPARATED FROM THE OTHER SPECIES

It is the policy of the Board, whenever possible, to retain the fish at the hatcheries, until they have attained an age and size, best fitted to cope with the conditions existing in our waters of today. This policy is also applied in the distribution of tadpoles. Consequently the great majority of them are distributed in the fall of the approach of the second year, that is when they are about sixteen months old.

By late fall, the leopard and pickerel frog tadpoles, have developed and disappeared. The remaining tadpoles, the green and bullfrog species, are then sorted into two sizes, by passing them through a series of accurately spaced, parallel bars. The extreme large sizes are retained in the sorters and are considered the bullfrog tadpoles approaching their second year. These are sent out for distribution. The smaller tadpoles of both species, having passed through the sorter are returned to the pond until the following spring, when they are again sorted, for the purpose of removing the green frog tadpoles approaching one year old. This is easily and rapidly accomplished for at this period the leg rudiments are present on the green frog tadpoles, which are not to be found on the bullfrog tadpoles of the same age, the older ones having been removed the previous fall. Many of the green frog tadpoles are utilized for bass food.

ARTIFICIAL PROPAGATION

A number of years ago, at one of our hatcheries, a series of unsuccessful attempts were made to artificially propagate and rear the frog. But a number of important facts were brought out that would probably be of interest to those contemplating its culture.

Frogs of all sizes had to be securely penned to keep them from migrating to more desirable quarters.

Enemies including the snake, birds, and certain water insects, had to be guarded against. The black crow proved to be very destructive to small frogs, and in order to save them the pens were covered with wire netting.

Because of their cannibalistic tendencies, sortings had to be made and the frogs penned according to size. For the same reason, the adult had to be removed from the areas containing the tadpoles.

None of the frogs could be induced to take artificial food, and their natural foods could not be obtained in sufficient quantities for retaining

ing a worth while number. The tadpoles fed readily on such foods as dead fish, ground sheep livers, and clabbered cows milk.

The mortality of the tadpole at the time of transformation was very high, and many of those that did develop into the frog, crowded into the corners of the pens, where they smothered and trampled one another to death. The crowding was probably due to their efforts to escape because of the shortage of natural food.

A portion of the water area in the pens had to be of sufficient depth to protect the frogs and tadpoles from frost during the winter months.

